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PRICE ADJUSTMENT IN LONG TERM CONTRACTS:  
THE CASE OF COAL

By  
Paul L. Joskow

Number 444

Revised March, 1987

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## ABSTRACT

A sample of coal contracts between electric utilities and coal suppliers is used to analyze mechanisms for determining prices in long term coal contracts. Alternative methods for determining prices in long term contracts are discussed and the actual adjustment mechanisms specified in a set of actual coal contracts presented. The vast majority of long term coal contracts use a base price plus escalation or cost-plus adjustment formula. Base price equations and subsequent transactions price equations are estimated. The analysis shows that on average long term contracts are flexible in the sense that prices adjust to major changes in the costs of supplying coal. However, some pricing rigidities are found which appear to reflect the economic conditions prevailing at the time the contracts were executed. Furthermore, some contracts track changes in market values very poorly.

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## Price Adjustment in Long Term Contracts: The Case of Coal

By

Paul L. Joskow<sup>1</sup>

### I. Introduction

In two previous papers<sup>2</sup> I analyzed empirically the role of relationship specific investments in the choice of contracts of various durations or vertical integration to govern transactions between electric utilities and coal suppliers. In this paper I examine how the parties to a long term coal supply contract provide ex ante for adjustments in transactions prices over time. I utilize a sample of about 250 coal contracts to analyze the structure of formal price adjustment provisions in coal contracts, to determine the factors that affect initial negotiate contract prices, and to examine actual transaction price behavior over time.

There has been a lot of recent theoretical work and some related empirical work that has focused on the benefits of long term contracts when relationship specific investments are important.<sup>3</sup> There has also been some theoretical work that focuses on the contractual arrangements that may be chosen to mitigate opportunism problems and guard against certain types ex post inefficiencies in performance.<sup>4</sup> However, I am aware of very little systematic empirical work that has examined how the parties to a long term contract provide ex ante for adjustments in the terms of trade as market conditions change through the life of the contractual relationship.<sup>5</sup> Furthermore, despite the importance of assumptions about price rigidity in macroeconomics (and to a lesser extent in microeconomics) and the association of price rigidity with explicit or implicit long term contracts, there has been very little systematic empirical analysis of the rigidity of actual transactions prices.<sup>6</sup> This paper seeks to expand our

empirical knowledge in these areas using data for coal contracts.

Coal supply arrangements are interesting for examining how long term contracts provide for and actually work in adapting to changing market conditions for several reasons. Electric utilities routinely enter into very long term coal supply relationships via contract. Contracts with specified durations of 20 years or more are frequently utilized. Creating price adjustment provisions in such contracts that do a good job adapting to changing market conditions while simultaneously preserving other benefits of long terms contracts would appear to be a formidable task. Yet coal supply relationships are rarely terminated prematurely <sup>7</sup> and utilities have continued to rely on long term contracts as market conditions have changed. It is reasonable to hypothesize that some way has been found to keep the costs of long term contracts low relative to their benefits.

The paper proceeds in the following way. The next section discusses alternative methods for price adjustment in long term coal contracts when such contracts have been chosen to ameliorate contracting problems that may emerge when relationship specific investments are important. Section three describes the structure of price adjustment provisions found in a sample of long term coal contracts. Section four presents an empirical analysis of the factors that determine initial coal contract prices at the time contracts are negotiated and adjustments in these prices over time for a sample of about 250 coal contracts. The final section contains some concluding remarks.

## II. Pricing Considerations In Long Term Coal Contracts

A consummation of a coal supply contract between an electric utility and a coal supplier involves agreement on numerous contractual terms and conditions. Among the most important are the price, the quantity, the quality

characteristics of the coal, the duration of the contractual commitment and provisions for adjusting one or more of these contractual provisions over time. I have argued elsewhere<sup>8</sup> that both the duration of coal contracts and the decision to internalize coal production through vertical integration are heavily influenced by the importance of relationship specific investments of the types described by Williamson.<sup>9</sup> The importance of relationship specific investments in coal supply relationships varies widely. As a result, there is also wide variation in the negotiated duration of coal supply contracts and the incidence of vertical integration. Historically, roughly 15% of coal purchased by electric utilities involves spot market transactions. Another 15% involves integrated supply. The rest involves coal supply contracts with contractually specified durations that vary between one year and fifty years.

Let us focus on a long term coal supply contract that involves deliveries of prespecified quantities of coal over a period of several years. In order for a supplier to agree to provide supplies, the present discounted value of expected future revenues must be greater than or equal to the present discounted value of expected future costs, including the opportunity costs of any future sales foregone by the seller by committing to a long term supply agreement. If coal markets are competitive, as they appear to be, buyers on average will pay no more than the present discounted value of expected future production costs (including rents and opportunity costs).

We can think of this expected present value price per unit supplied as being composed of several components. These include the present value of expected future operating cost (labor, material and supplies), capital costs, and any expected economic rents that may accrue to infra-marginal coal leases at each point in time over the life of the contract.<sup>10</sup> So we expect the payment provisions in a coal contract to satisfy:



$$(1) P = L + M + K + R$$

where:

P = the present value of expected future revenues per unit of coal supplied

L = the present value of expected future labor costs per unit of coal supplied.

M = the present value of expected future materials and supplies costs per unit of coal supplied.

K = the present value of the expected cost of capital invested per unit of coal supplied.

R = the present value of expected economic rents or opportunity costs per unit of coal supplied which clears the market and accrues to the owners of mining rights to inframarginal coal deposits ( $R \geq 0$ ).<sup>11</sup>

It is reasonably straightforward to relate coal production associated with a specific contract to the "variable" costs of labor, materials and supplies, and perhaps economic rents. It is more difficult to relate a specific contract to costs associated with capital investments required to provide supplies since the capital investments may have an economic life that is longer than the term of a specific contract. This is further complicated when the supplier makes relationship specific investments. Let us assume that the buyer and seller deal with the the relationship specific investment problem when they establish the duration of the contractual commitment and associated notice and termination provisions.<sup>12</sup> We can then think of their being a time stream of expected annual rental costs for capital equal to the opportunity cost of investment funds plus economic depreciation which is independent of observed differences in contract duration. I examine whether or not initial contract

prices are independent of the duration of the contract negotiated at the time it is executed in the empirical work reported below.

There are many different payment profiles that could satisfy equation (1). In principle, there exists a fixed price contract that satisfies (1) reflecting current and future costs and market price expectations at the time the contract is negotiated. If coal markets are competitive a "market price" contract in which the buyer and seller simply agreed to base future payments on the "market price" for comparable coal supplies at the time of delivery could be relied upon to satisfy equation (1) as well. A contract that specifies a base price to reflect current production costs, the current annual rental cost of capital investments, and economic rents combined with escalation provisions to reflect changes in production and opportunity costs over time could also be designed to satisfy (1). Numerous mixtures of fixed price plus escalating price formulas could be designed to satisfy (1) as well.

We can narrow down the likely structure of mutually satisfactory price adjustment provisions in long term contracts by recognizing that the parties are likely to want to structure price adjustment provisions to achieve certain objectives in addition to satisfying equation (1). These include (a) a desire to guard against "opportunism", "hold-up" or haggling problems associated with the presence of relationship specific investments, (b) a desire to minimize the incentives the contractual provisions themselves give the parties to breach their contractual promises, (c) a desire to provide enough flexibility to facilitate efficient adaptations to changing market conditions and, (d) since the price the buyer (a regulated electric utility) can charge customers for the final product is in this case regulated by state and federal regulatory agencies, to avoid pricing provisions that might lead a regulatory

agency to disallow a fraction of the coal costs as being "imprudent".<sup>13</sup>

a. Fixed Price Contracts

In a world in which nominal production costs are expected to increase over time, a fixed price contract that reflects ex ante expectations of future cost increases is likely to have bad properties from all of these perspectives. A long term fixed price contract necessarily "front loads" the revenues and expected profits of the seller relative to the flow of costs when nominal costs are expected to increase over time. A fixed price that satisfies (1) will involve an initial price that is high relative to current spot prices, high relative to prices in older fixed price contracts, and high relative to current production costs. If actual cost changes equal the ex ante expected changes in costs, at some point later in the term of the contract the price will be below then current spot market prices and below the prices in new fixed price contracts. If the expected rate of cost increase is fast enough and the contract long enough, the fixed price could fall below then current costs of providing incremental supplies at some future date. In either case, the seller will have strong incentives to breach on quantity or quality promises both because he can sell his supplies elsewhere at a higher price and possibly because the additional direct costs of meeting his commitments may be greater than the revenues he will receive. If production costs and market prices rise more quickly than anticipated the seller will face even stronger incentives to breach.<sup>14</sup> While the buyer can always appeal to the courts to enforce the contract or to award damages this route is costly and the results uncertain.<sup>15</sup> While almost any price adjustment provision could lead to large disparities between contract prices and "market prices" if certain contingencies arise and thereby provide incentives for either the buyer or the seller to breach, a fixed price contract almost guarantees that these problems

will arise even if there is no uncertainty about how costs and market values will change over time.<sup>16</sup>

Of particular relevance to regulated electric utilities is the fact that an agreement to a fixed price contract which involves initial prices that are far above current "market" prices is not likely to be treated very favorably by their regulators especially since fuel costs are generally passed through directly to customers through fuel adjustment mechanisms.<sup>17</sup>

For all of these reasons it is unlikely that an electric utility buyer and coal supplier would find a fixed price long term contract mutually satisfactory in a world where nominal costs and prices are expected to rise over time or where there is a possibility that uncertain events will occur that will lead to cost or price increases or decreases that are significant different from expected values.

#### b. Market Price Contracts

A potentially attractive alternative to a fixed price contract would be a "market price" contract. Such a contract would involve the parties simply agreeing that prices will be adjusted to reflect changes in the "market price" of coal with identical quality attributes available from (approximately) the same location as the coal that has been contract for.<sup>18</sup> If coal markets are competitive we would expect that the expected PDV of future market prices would satisfy (1). A market price provision eliminates any incentives the buyer or seller may have to breach the agreement as a result of better alternative opportunities during the term of the agreement. The pricing provision is in theory easy to state and easy to enforce by the courts and therefore is potentially attractive to guard against ex post opportunistic behavior. If the supplier produces efficiently it is unlikely that the price will fall below his incremental cost of meeting his contractual commitments



and if it does he could meet them by buying rather than producing (and this would be efficient). This price adjustment mechanism would be potentially very attractive for electric utilities concerned about prudence reviews based on comparisons between contract prices and some measure of the "market price."

The primary problem with a "market price" contract is defining an appropriate market price norm to use for this purpose. Coal is not a homogeneous commodity. There are wide variations in heat content, sulfur content, ash content, moisture content and chemical composition all of which affect the value of coal to buyers and market prices. Because transportation costs are an important component of the delivered price of coal, prices at the mine also vary from area to area to reflect proximity to coal consumers and the costs of transportation.<sup>19</sup> While the government reports the average FOB mine price per ton by producing district (with a considerable lag), there is no breakdown between spot and contract prices FOB the mine.<sup>20</sup> and only limited information that would make it possible to accurately adjust for differences in coal quality or variations in the "quality" of the coal supply relationship. Even within producing districts that have reasonably homogeneous coal deposits there is a very wide variation in FOB mine prices observed at any point in time. In short, there does not appear to be a single simple number that a contract can rely on as a good indicator of the relevant market price of coal.

The use of a market price norm in long term contracts where relationship specific investments are important is further complicated by the way damages are likely to be assessed if there is a breach of contract. The essence of a contractual relationship involving relationship specific investments is that there is an expected cost to one or both parties of premature termination that is associated with the investments that they have sunk in anticipation of



performance. Ideally, the damages that would be assessed if either party breached the agreement should reflect these "relationship specific" costs. But if the parties simply agree that they will trade at the "market price," a breach may lead to damages that bear no necessary relationship to the true costs of a breach. If the seller breaches the buyer would be expected to replace the coal at "the market price" which is also what the buyer agreed to pay the seller, so arguably there may be no damages to the buyer. Similarly, if the buyer breaches, the seller would be presumed to dispose of the supplies at "the market price," which is arguably what he would have been paid anyway.<sup>21</sup> Aside from costs associated with lost sales or the use of more costly substitute generating capacity due to lags in finding a new buyer or seller this could lead, incorrectly, to the a conclusion that there were no damages from the breach. If some other method is used to specify the transactions price in the contract that does not depend directly on observed market prices, however, the difference between the contract price and what the buyer must pay to replace the supplies or the seller receives when he finds other buyers becomes a natural basis for comparison for purposes of damage computation.

All things considered, therefore, I would not expect the parties to rely overtly on a simple "market price" provision for determining transactions prices in long term coal contracts even if the parties desire to establish a pricing provision that at least roughly tracks changes in market values over time. When such a provision is included, I would expect that it would specify exactly how the relevant "market price" is to be determined, in order to avoid haggling over the proper benchmark and to serve as a basis for damage calculations.

### c. Escalating Price Contracts

But for the problems associated with coming up with an appropriate norm

and the problems associated with protecting relationship specific investments from premature breach or termination, a simple market pricing mechanism has the attractive property that it minimizes incentives to breach that arise because of differences between contract prices and market values. It would be desirable to devise a pricing formula that satisfies equation (1) and (a) provides for a clear specification of the agreed upon contract price that does not depend directly on "market prices", (b) which, over the term of the contract, would come reasonably close to tracking the market value of the coal, and (c) which provides a basis for properly assessing damages associated with the loss of relationship specific investments.

Over the long term we expect that coal prices will change as the costs of production (including rents and opportunity costs) rise and fall, other things equal. It is natural therefore to think of starting with a base price that reflects current supply and demand conditions and then allowing it to vary with changes in the costs of producing coal. This might be accomplished by structuring a contract that establishes an initial or base price equal to the seller's current productions costs plus an economic rent component and then provides for prices to change along with the seller's actual costs of production (e.g. some type of cost plus contract). There are at least three potential problems with a cost plus contract, however. First, it has bad incentive features from the perspective of inducing minimum cost supply by the seller. Second, even if a particular supplier makes his best efforts to supply efficiently, a specific mine may turn out to be significantly higher cost or lower cost than the typical mine and contract prices may consistently be above or below the market value of the coal. Third, it will not be sensitive to unanticipated changes in market supply and demand conditions that would affect market values more or less than changes in the supplier's costs of

production.<sup>22</sup> In each case, costly haggling and renegotiation problems resulting from large differences between contract prices and prevailing market values may make this contracts unattractive.

An alternative to a cost plus contract is a contract that specifies a base price reflecting supply and demand conditions when the contract is signed and which then provides for adjustments in the base price using a formula that incorporates a weighted average of exogeneous input price indices reflecting the anticipated input/output mix of the supplier, combined with exogenous indices of changes in labor and capital productivity reflecting "general" changes in production opportunities. Instead of using the actual costs incurred by a specific seller to adjust prices, exogenous indices reflecting general market opportunities are at least partially used. These contracts are generally called "base price plus escalation" (BPE) contracts.

As long as the market value of the coal moves along with changes in input prices, general productivity changes affecting comparable mines, etc. this approach seems superior to a cost plus contract. It helps to solve the first incentive problem associated with pure cost plus contracts, since prices are at least partially decoupled from the actual costs incurred by a specific supplier. Similarly, it solves the second problem associated with a mine that it unusually costly or unusually efficient. It does not solve the third problem, however. Indeed, there is no obvious way to solve the third problem without tying contract prices to market values directly in some way. With either a cost plus contract or a BPE contract it is impossible to track large short run changes in the market value of coal associated with demand side shocks. Short run supply side shocks would be more easily captured, but certainly not perfectly. If one of these adjustment mechanisms is chosen, the parties would have to recognize that serious haggling problems may emerge if

markets are subject to unanticipated demand or supply side shocks which lead to large increases or decreases in the expected market value of coal over the term of the contract.

Clearly, none of the price adjustment alternatives is ideal. Long term (nominal) fixed price contracts are simply not credible in a market like this and I would not expect them to be used extensively.<sup>23</sup> Market price contracts are attractive but both the difficulty of defining an appropriate market price norm and the problem of providing for damage penalties that appropriately reflect the quasi rents associated with the difference in value of relationship specific investments between the intended use and alternative uses implies that they will not be relied on very much in coal markets except in special circumstances.<sup>24</sup> Both BPE and cost plus contracts have attractive features in that both could do a reasonably good job of tracking market values in the long run as long as changes in market values move closely with changes in the average cost of production. Large unanticipated demand or supply side shocks could lead to problems, however.

### III. Typical Pricing Provisions In Long Term Coal Contracts

I have general descriptive information on the method used to adjust prices for 158 of the contracts<sup>25</sup> in the data base discussed in the Appendix. In addition, in the course of my research on coal contracts I have had the opportunity to review over 80 actual coal contracts (plus amendments) in more detail.<sup>26</sup> Table 1 breaks down these 158 contracts by method of price adjustment. The vast majority of the contracts use a BPE adjustment formula. About 15% of the contracts are listed as cost-plus (often with an incentive fee provision indicated) and about 7% of the contracts provide for negotiated prices or prices tied to some market basket. Six of the eleven contracts in the latter category have durations of five years or less.<sup>27</sup>

Table 1  
Price Adjustment Mechanisms Found in 158 Long Term Coal Contracts  
In Force in 1979

Base Price Plus Escalation:	123
Cost plus:	24
Negotiated or market price:	<u>11</u>
TOTAL	158



The typical long term coal supply contract thus uses a base price plus escalation (BPE) pricing formula in which an initial base price is set when the contract is negotiated and then adjustments are made to the base price using a weighted average of changes in external input price and productivity indices and changes in actual costs. For example, a contract might specify of base price of \$30 per ton (with coal quality attributes specified elsewhere in the contract) and then break down the base price into several different components:

Labor component:	\$10.00
Materials & Supplies:	5.00
Explosives:	2.00
Electricity:	1.00
Other (profit, depreciation, royalties):	12.00

The contract then includes provisions for adjusting each of these components for changes in input prices or productivity based on either an exogenous index or the supplier's actual cost experience. For example, the labor component might be adjusted for changes in actual labor costs or changes in union wage settlements or sometimes an index of local area mining wages. Especially when a wage index is used the contract is likely to include a manning table which fixes a base manhours per ton (adjusted for wage differences among different types of workers) figure. The latter is normally subject to further adjustment for changes in work rules and labor productivity mandated by changes in union wage agreements or government regulations.

The materials and supplies component (explosives and electricity are often broken out as separate components) is typically indexed to a weighted average of several sub-indexes of the Producer Price Index (e.g. tractor

tires, rubber belts and belting, construction machinery and equipment, lubricating oil, fuel oil, etc.). The explosives component is generally adjusted for changes in the wholesale price index for explosives. Finally, the electricity component would be adjusted for changes in the applicable retail rate charged by the local electric utility.

There is substantial variation among contracts in how much the "other" category is broken down. Sometimes separate "profit", "depreciation" and royalty components are specified. More typically there is just a residual component called "other." This component is generally either partially or fully indexed to changes in a general price index like the wholesale price index or the consumer price index.

The contracts that I have reviewed almost always provide for additional adjustments to reflect the costs of meeting new government regulations, changes in property and excise taxes, changes in third-party royalty payments, etc. As inflation was recognized as being a more severe problem in the mid and late 1970's it also appears that scheduled price adjustments have become more frequent. Before the early 1970's annual or quarterly adjustments were typical. Quarterly adjustments and then monthly adjustments appear to have been have been used more after 1974. Indeed, the speed of adjustment has been one item that has sometimes been renegotiated by the parties. Furthermore, it appears that as inflation became more important, base prices have been broken down into finer and finer components, more sub-indexes have been incorporated in the adjustments to the M&S component and the "other" category is much more likely to be fully rather than partially indexed.

Finally, many contracts include reopener provisions based on "gross inequity" to the buyer or the seller and force majeure provisions to protect the buyer and seller from certain unanticipated events. These provisions are

most likely to be applicable when changes in production costs get far out of line with changes in adjusted prices, when government regulations are imposed that have significant effects on the costs of mining and were not anticipated by either party when the contract was executed, or when government regulations on emissions constrain the ability of the buyer to make use of the quantities of coal that have been contracted for. Deviation of contract prices from "prevailing market prices" alone is not generally an excuse for invoking either type of adjustment clause, however.

It thus appears that prices in long term coal supply contracts are "flexible" in the sense that prices can change over time in response to changes in the costs of production. However, they appear to be "inflexible" in the sense that they do not respond to changes in market values that are not reflected in changes in the average costs of production as provided for by BPE or cost plus adjustment formulas. There is no reason to believe, for example, that long term contract prices will move up or down in lockstep with spot market prices.

#### IV. The Behavior Of Coal Prices For Coal Sold Under Long Term Contracts

In this section I examine empirically the actual behavior of coal prices for coal sold under long term contracts. I am particularly interested in examining the factors that determine the initial or base prices that the contracting parties agree to and how these prices have adjusted over time. The approach is very simple. As discussed in more detail in the Appendix, I have constructed a data base that contains information for nearly 300 coal contracts negotiated between the late 1950's and 1979.<sup>28</sup> For most of these contracts the data base includes the initial (nominal) base price FOB the mine (per million BTU) specified in the contract as well as for the actual average

price FOB the mine for coal supplied pursuant to these contracts in 1979, 1980 and/or 1981. I have information on two important quality attributes of the coal, its btu content and its sulfur content, information on where the coal is mined, information on when the contract was executed, and information on the negotiated contract duration specified at the time the contract was executed.

First, I estimate an equation to explain the observed base prices for coal. This equation allows us to identify the factors that determine the initial negotiated base prices in coal contracts, to compare negotiated base prices for new contracts signed during a particular period with the average price prevailing for all coal transactions in a particular year, and to see how base prices have varied over time with changing market conditions. Next, I estimate a set of equations to explain actual transaction prices resulting from these contracts in three different years subsequent to the formation of the contract and the specification of a base price. These transactions prices presumably reflect the workings of the price adjustment provisions discussed above plus mutually beneficial renegotiation of contract terms. These equations make it possible to compare transactions prices at a particular point in time pursuant to contracts negotiated at different points in time.

Before proceeding with the statistical analysis it is useful to discuss the general patterns of coal prices and changing market conditions over the period for which we have base price and transactions price data (1960 - 1981). Table 2 provides information reported by the Department of Energy (DOE) for the average price of coal at the mine (per million BTU's) sold in the U.S. by year between 1960 and 1981. The prices reflect both contract and spot market transactions. The first column gives the nominal prices and the second column gives the real prices (\$1972) using the GNP deflator. The third column is an index of average labor productivity at coal mines. Nominal prices are fairly

Table 2

Average Transactions Price For Coal  
 1960 - 1981  
 (cents/million btu)  
 FOB Mine

<u>Year</u>	<u>Nominal Price</u>	<u>Constant \$1972</u> (GNP Deflator)	<u>Labor Productivity</u> <u>Index (1968=100)</u>
1960	18.9	27.5	63.9
1965	18.0	24.2	91.1
1970	26.4	28.9	98.0
1971	29.2	30.4	93.8
1972	32.9	31.5	92.3
1973	36.7	34.7	91.5
1974	68.6	59.6	91.5
1975	84.3	67.0	76.7
1976	85.0	64.2	75.2
1977	88.2	63.0	77.2
1978	98.5	65.4	76.4
1979	105.7	64.7	79.8
1980	109.7	61.5	84.9
1981	118.2	60.6	94.1

Source: Statistical Abstract of the United States, various years



constant between 1960 and 1965 and real prices fall slightly. Both nominal and real prices then begin to rise. Real prices are about 20% higher in the 1971-1973 period than they were in the mid-1960's. Real prices take a big jump in 1974 and 1975 and then decline slightly. Nominal prices rise throughout the entire period.

The general pattern of average price changes that we observe is not terribly surprising. The period covered in Table 2 is one of substantial change in coal markets. Coal price movements reflect a combination of supply side changes affecting the costs of producing coal and demand side changes. After a period of declining or stagnant coal production lasting into the early 1960's, coal production increases gradually but significantly between 1965 and 1973 (about 20%). Especially by 1970, contemporary discussions of the market indicate that supply was tight. After 1973, coal production increases more rapidly, and by 1981 production is about 35% higher than in 1973. The increases in coal production reflect primarily increased utilization of coal by electric utilities.

Large increases in oil prices in 1974 and 1975 made coal a much more attractive fuel for generating electricity and almost certainly increased the expected demand for coal in the long run significantly. The short run effects on coal consumption by electric utilities appear to have been modest, however.<sup>29</sup> Large increases in oil prices in 1978 and 1979 had a larger effect on short run coal demand. The large price increase accelerated conversions of plants from oil to coal in the East and led to increases in purchased power transactions ("coal by wire") between the midwest and the east and between the Southwest and the Pacific regions.<sup>30</sup> At the same time, long run projections of coal demand began to be reduced as it was becoming clear that electricity demand would grow more slowly than anticipated and utilities began to slow

down capacity additions of all kinds. By this time oil and gas prices had risen far enough that no new oil or gas fired generating capacity was anticipated in any event.<sup>31</sup> The primary effect of the oil price increase in 1978-89 was probably to increase the short run demand for coal at a time when long run projections of coal demand were declining and a great deal of new production capacity was becoming available.<sup>32</sup>

Federal mine safety regulation began to affect the costs of supplying coal by about 1970.<sup>33</sup> Additional safety and health regulations affecting mining were introduced during the 1970's and are also thought to have increased costs.<sup>34</sup> Federal and state environmental regulation passed during the 1970's affecting land reclamation procedures and the disposal of mine wastes are also likely to have increased costs during the 1970's.<sup>35</sup> Coal mine productivity declines from about 1969 to 1977 and then begins to increase. Federal and state environmental regulations affecting power plant emissions shifted the demand for coal toward low-sulfur and ash coal which in turn greatly increased the demand for western coal. After 1973, the coal industry was affected by the high rate of inflation in input prices as was the rest of the economy.

The most significant change in the real prices occurred between 1973 and 1975 after the first oil price shock. Both demand side and cost side shocks are consistent with the behavior. On the cost side, average labor productivity (See Table 3) declined by nearly 20% between 1973 and 1975 (essentially all of this occurs between 1974 and 1975). Real wages for coal miners increased by about 10% during this two year period as well. The real prices for equipment and materials and supplies used in coal mining (construction equipment, fuel oil, electricity, explosives) also increased dramatically during these two years.<sup>36</sup> A significant portion of this increase would probably have been picked up by many BPE adjustment formulas and reflected in prices under

existing contracts, especially those adjustment formulas that had labor productivity adjustments.

a. Base Price Equations

Clearly, any effort to analyze base prices and subsequent transactions prices must take account of the changing market conditions that characterized the demand and supply of coal during this period. Let me turn first to a discussion of the base prices in BPE and cost-plus type contracts.

Base prices FOB the mine should vary directly with the quality of the coal (Btu and sulfur content), the supply region that it comes from and when the contract was negotiated. I expect that the higher the Btu content of the coal the higher will be the price, other things equal. High Btu coal is more valuable than low Btu coal for several reasons. First, the thermal efficiency of electric generating plants varies directly with the Btu content of the coal.<sup>37</sup> Second, the cost of building a generating unit with a specific design temperature and pressure varies inversely with the Btu content of the coal it is designed to burn.<sup>38</sup> Third, the cost of transporting coal per Btu of useable energy must be lower for high Btu coal than low Btu coal.

I also expect that high sulfur coal will be more valuable than low sulfur coal, after approximately 1970,<sup>39</sup> as a consequence of changes in sulfur emissions regulations applied to electric utilities. The FOB mine prices for coal should be significantly lower for coal produced in the Western region, after accounting for differences in Btu and sulfur content, to reflect the much higher average transportation distance to utilities compared to coal supplied from mines in the Midwest and East. While I allow for price differences between Midwestern and Eastern supply regions as well in the empirical work reported below, these differences should be much smaller because there is little difference in average transport distance.

Since we are looking at nominal base prices there should be differences in negotiated base prices over time as well. These differences should reflect both changes in nominal input prices and real changes in supply and demand conditions. In what follows I generally group the contracts into four time periods. The first period covers contracts negotiated before 1971. The second covers contracts negotiated between 1971 and 1973, after federal sulfur emissions restrictions were announced and the first major new federal mine safety legislation began to take effect, but before oil prices increased dramatically and before inflationary concerns became severe. The third period is 1974 through 1977, after the initial large increases in world oil prices and more stringent environmental and health and safety regulations were imposed on the coal mining industry and when concerns about rapid inflation in input prices probably got more attention in coal contracting. The fourth period is 1978-1979 when oil prices rose again, the rate of inflation increased, coal markets began to "cool down" somewhat due to declining projected rates of growth of electricity demand and increases in coal production capacity.

The contracts in the data base vary widely in the duration for which the parties agreed to abide by the terms and conditions of the contract when it was executed. If, contrary to my expectation, coal contracts have a significant fixed price component which "front loads" future expected costs, then those contracts with longer terms should have higher base prices, other things equal. Similarly, if the buyer or the seller tried to use the level of the base price to as a sort of financial "hostage",<sup>40</sup> rather than relying on variations in the term of the agreement to amortize relationship specific investments, base prices could vary systematically with the negotiated term of the agreement. Accounting for variations in the agreed upon duration of a coal



supply agreement at the time it was signed in the base price equations allows us to determine whether or not these effects are present.

I begin by estimating the following linear base price relationship which measures regional and time related effects relative to Eastern coal contracts signed in the 1978-1979 period.<sup>41</sup> Variable definitions and summary statistics for each variable are reported in Table 3.

$$\begin{aligned} (2) \quad \text{BASE PRICE} = & a + b_1T1 + b_2T2 + b_3T3 + b_4\text{MIDWEST} + b_5\text{WEST} + b_6\text{BTU} \\ & + b_7\text{SULF} * T1 + b_8\text{SULF} * T2 + b_9\text{SULF} * T3 + b_{10}\text{SULF} * T4 \\ & + b_{11}\text{DURATION} + v \end{aligned}$$

where  $v$  = iid error term

If base prices generally reflect prevailing supply and demand conditions at the time a contract is signed I would expect to observe the following pattern of coefficient estimates. The coefficients of T1, T2 and T3 should all be negative and decline monotonically in absolute value since nominal coal prices generally rise throughout this entire period. The coefficient of WEST should be negative reflecting the relatively long average transport distances for Western coal. The coefficient of BTU should be positive reflecting the higher value of high BTU coal. The coefficient of SULF should be negative to reflect the relatively lower values associated with high sulfur coal due to environmental regulations. The coefficient of DURATION should be zero unless base prices include a significant fixed price or financial hostage components. Finally, if we use the estimated relationship to "predict" base prices for new contracts in each period the resulting values should track changes in prevailing market conditions fairly closely, although prevailing market conditions will be difficult to measure precisely.



TABLE 3

Variable Definitions and Summary Statistics

<u>Variable</u> (observations)	<u>Description</u> <sup>1</sup>	<u>Mean</u>	<u>Minimum</u>	<u>Maximum</u>	<u>Standard</u> <u>Deviation</u>
BASE PRICE (247)	Initial Base Price specified in each contract	71.26	8.00	158.00	38.43
PRICE79 (226)	Actual Transaction price in 1979	102.58	15.00	175.00	30.46
PRICE80 (200)	Actual Transaction Price in 1980	109.20	28.00	187.00	34.80
PRICE81 (173)	Actual Transaction Price in 1981	124.68	31.00	321.00	42.96
BTU (247)	Average Btu content per pound of coal	11471	8000	15150	1353.4
SULF (247)	Average % sulfur content of coal	1.89	0.35	6.50	1.18
DURATION (243)	Negotiated Contract Duration at contract execution	12.42	1.0	43.0	10.33
MIDWEST (247)	Dummy Variable that equals 1 if coal is supplied from mid- western region		60 Observations		
WEST (247)	Dummy Variable that equals 1 if coal is supplied from western region		49 Observations		
T1 (247)	Dummy variable equals 1 for contracts signed before 1971		36 Observations		
T2 (247)	Dummy variable for contracts signed 1971-73		39 observations		
T3 (247)	Dummy variable for contracts signed 1974-77		103 observations		
T4	Dummy variable for Contracts signed 1978-79		69 observations		

<sup>1</sup> All prices are in cents per million Btu's of coal.

OLS estimates of the coefficients of (2) may be biased because of the nature of the sample of coal contracts that I make use of. As discussed in Joskow,<sup>42</sup> the sample is based on contracts in force in 1979, rather than all contracts written over time. We observe contract prices only if contract duration ( $y$ ) is greater than or equal to  $(1979 - t_i)$ , where  $t_i$  is the contract execution date, so we have a censored sample. This implies that the random error ( $v$ ) in the base price equation (2) may be correlated with the random error ( $u$ ) in a second contract duration equation<sup>43</sup> as a consequence of the sampling procedure. If this is the case, the random error ( $v$ ) in the price equation will be a function of the independent variables in such a contract duration equation. OLS estimates of the coefficients of the independent variables in the price equation (2) would then be biased if they are correlated with the independent variables in the duration equation. In particular, independent variables that appear in the contract duration equation may appear to be significant when introduced as independent variables in equation (2) when in fact they are not<sup>44</sup>. Since three variables that appear in the price equation (2) also appear in the duration equation that I estimated in my earlier paper this is a potential problem here.

Very simply, the problem with OLS estimation of (2) is that it ignores the potential presence of a "missing variable" which is equal to the mean of  $v$  conditional on the sample selection rule and the specification of a contract duration equation. The conditional mean of  $v$  given the sample selection rule and assuming that both equations are linear and the joint density of  $u$  and  $v$  is bivariate normal is given by:

$$(3) \quad E(v_i | y_i \geq (1979 - t_i)) = s_{uv}H_i ; L_i = (1979 - t_i); y_i = \beta'x_i$$

and:

$$(4) \quad H_i = \frac{\left(\frac{1}{\sigma}\right)g\left[\frac{(y_i - \beta'x_i)}{\sigma}\right]}{\left[1 - G\left[\frac{(L_i - \beta'x_i)}{\sigma}\right]\right]}$$

$s_{uv}$  is the covariance of  $u$  and  $v$ ,  $y_i$  is the duration of contract  $i$ ,  $t_i$  is the year contract  $i$  was negotiated,  $g(\cdot)$  is the standard normal density function and  $G(\cdot)$  is the standard normal distribution function.

We can obtain consistent estimates of the coefficients of (2) by making use of information obtained from the ML estimates of the duration equations estimated in Joskow (1987) to generate a consistent estimate of  $H$  for each observation, adding the estimated values for this variable to (2) and then running OLS to the augmented model. The coefficient of  $H$  is then a consistent estimate of the covariance of  $u$  and  $v$ .

Table 4 report OLS estimates of the coefficients of equation (2) in column (1) and estimates of equation (2) with  $H$  included in column (2). Estimates of the coefficients of equation (2) with the coefficient of  $SULF$  constrained to be equal across periods are reported in column (3). Finally, estimates of equation (2) without  $DURATION$  or  $H$  are reported in column (4).<sup>45</sup>

Note first that the coefficient of  $H$  is insignificant and the coefficient estimates are not sensitive to its inclusion, so that there does not appear to be a serious censoring problem associated with the data used to estimate the base price equations. Second, constraining the coefficient of  $SULF$  to be identical across periods does not change the estimated coefficients in important ways. It is quite clear, however, from an examination of the estimated dummy variables in this case that nominal base prices have risen significantly over time. I will return to this in a moment. In any event, we can reject the hypothesis that the effects of sulfur on coal prices is the same in the pre-1971 period as it is in the later periods at the 5% level ( $F(1,229) = 4.25$ ) .

Table 4

Base Price Equations  
(standard errors in Parentheses)

Dependent Variable: BASE PRICE

<u>Variable</u>	<u>(1)</u>	<u>(2)</u>	<u>(3)</u>	<u>(4)</u>
Constant	53.641 (20.139)	59.457 (20.408)	49.588 (18.756)	55.679 (19.770)
T1	-93.740 (8.586)	-95.805 (8.760)	-77.953 (4.959)	-92.705 (7.841)
T2	-62.440 (7.723)	-65.041 (7.780)	-64.421 (4.218)	-61.608 (7.334)
T3	-32.377 (5.741)	-35.219 (5.898)	-26.292 (2.861)	-31.720 (5.567)
MIDWEST	-0.00068 (3.778)	-0.401 (3.842)	-1.207 (3.687)	0.702 (3.711)
WEST	-22.302 (5.172)	-22.084 (5.332)	-20.700 (5.281)	-21.445 (5.058)
BTU	0.00567 (0.00150)	0.00555 (0.00150)	0.00565 (0.00145)	0.00553 (0.00148)
SULF1	0.110 (2.157)	0.270 (2.194)	-	0.133 (2.133)
SULF2	-8.074 (3.231)	-7.744 (3.238)	-	-8.591 (3.188)
SULF3	-2.642 (1.912)	-2.387 (1.912)	-	-2.867 (1.884)
SULF4	-6.309 (2.229)	-7.255 (2.277)	-	-6.388 (2.215)
SULF	-	-	-3.189 (1.355)	-
H	-	-9.002 (12.184)	-2.937 (12.173)	-
DURATION	0.0972 (0.163)	0.0215 (0.173)	0.0472 (0.175)	-
R <sup>2</sup> (corrected)	0.80	0.80	0.80	0.81
NOBS	243	240	240	247

Focusing on the first column of Table 4, we find that the estimated coefficient pattern is just what we expected. High quality (BTU) coal has a higher price per million btu's than does low quality coal. There is a significant penalty associated with sulfur content (i.e. a negative coefficient on SULF), after 1970, but not earlier. Coal supplied from the Western producing region has a significantly (numerically and statistically) lower price than coal produced elsewhere. There is no significant difference in prices for coal supplied from mines located in the East and Midwest. The estimated coefficient of DURATION is also insignificantly different from zero and is very small.<sup>46</sup>

The fact that DURATION has no effect on base prices is consistent with the view that base prices generally reflect prevailing market conditions and do not embody significant fixed price components reflecting the front loading of future expected nominal cost increases. To explore this phenomenon further, we can use the estimated equation reported in Table 4 to generate base price predictions for contracts signed in different time periods. Base price predictions using column (4) of Table 4 are reported in Table 5.<sup>47</sup> The first column of Table 5 provides such estimates using the sample means for the independent variables in equation (2). The second column is the average price for all coal transactions reported by the DOE during each time period based on the figures in the first column of Table 3. The figures in this column included both contract and spot market purchases.

It is clear from Table 5 that the predicted average base price in new contracts tracks contemporaneous average transactions prices fairly closely. To the extent that the average transactions price for all coal transactions is a good indicator of "prevailing market conditions" this result suggests both that base prices are established to reflect prevailing market conditions and



Table 5

Predicted Base Prices And Average Transactions Prices  
(cents per million Btu, FOB Mine)

<u>Contract Period</u>	<u>Predicted Base Price</u>	<u>Contemporaneous Average Transaction Price</u>
pre-1971	22.6	21.1
1971-1973	37.2	32.9
1974-1977	77.9	81.5
1978-79	103.0	102.1

Source: Predicted base prices are calculated from Table 4 column (4) using the sample means of the independent variables. Actual average transactions prices for all coal sold during each period (contract + spot) calculated from Table 2.

that contractual price adjustment provisions combined with mutually satisfactory renegotiation, do a reasonably good job in tracking changes in market conditions.<sup>48</sup>

b. Subsequent Transactions Price Equations

We can get better insights into price rigidity by more carefully analyzing contemporaneous transactions prices associated with contracts negotiated in different coal market "eras." To do so I turn next to an analysis of the actual transactions prices that emerged in three different years subsequent to the time the contracts were executed and an associated base price and adjustment mechanism agreed to using information on actual transactions prices by contract for the subsequent years 1979, 1980 and 1981 (see Table 2).<sup>49</sup> I estimate exactly the same relationship as (2) above, without DURATION,<sup>50</sup> using actual transactions prices for 1979, 1980 and 1981 rather than base prices. I report separate estimates for the transaction price relationship using transaction price data for each of these three years and also pool the three years of transaction price data. In the latter case, dummy variables for transactions recorded for 1979 and 1980 are included (PRICE79 and PRICE80) as well to account for adjustments in nominal prices over the three year period.

If the formal BPE contracts are meaningful in the sense that the initial base price and the associated adjustment provisions specified in the contract do affect future transactions prices then we should observe some specific patterns of price rigidity. In particular, it is likely that we will find significant differences in transactions prices between pre-1974 contracts and later contracts. As I indicated above, the structure of the typical price adjustment provisions of long term coal contracts appear to provide, in one way or another, for price adjustments that reflect changes in the average

costs of producing coal. They do not appear to provide for adjustments that reflect changes in the average economic rent that a supplier might earn due to unanticipated changes in demand expectations or supply side changes that increase the costs of producing from marginal properties more than the average cost of production. These are exactly the kinds of changes that are likely to have occurred after 1973.

After 1973, the expected demand for coal increased substantially and it is reasonable to hypothesize that the present discounted value of future economic rents increased on average. Zimmerman's estimates suggest that the effects of long run increases in future demand on prices in 1980 should be fairly small since the long run supply function for coal is quite elastic.<sup>51</sup> Short run demand shocks may have increased prices in the short run much more, however. Furthermore, cost increases due to input price changes, productivity changes and environmental and safety regulations increased more rapidly as time went on. While contractual provisions are generally in place to protect the supplier from these changes, they are likely to be imperfect, and are probably more imperfect for pre-1974 contracts than for later contracts. The post-1977 contracts are likely to be the best protected of all. The pre-1970 contracts are less likely to have anticipated the possibility of major increases in costs due to environmental, health and safety regulations and the general deterioration in labor productivity. The pre-1974 contracts are less likely to have anticipated the very high rates of input price inflation of the mid and late 1970's and probably provided for less detailed and less frequent adjustment of base prices to cost changes. To the extent that these cost increases affected the costs of producing from new properties more than from existing mines, there would be an associated potential economic rent attributable to older contracts that would not actually appear in higher

prices due to contractual rigidities.<sup>52</sup> These considerations make it likely that "rigid" pre-1974 contracts yielded transactions prices during the 1979-81 period that were lower than contemporaneous transactions prices for post-1974 contracts. Differences between the contracts negotiated from 1974-1977 and those negotiated in 1978 and 1979 are likely to be distinguished primarily by the frequency of adjustment and perhaps the use more detailed adjustment formulas, but should probably have fairly comparable prices.

Table 6 provides estimates of transactions price equations for 1979, 1980 and 1981 transactions along with an estimate of a transactions price equation using the pooled data and allowing for different intercepts for 1979, 1980 and 1981. Estimates with (OLS/H) and without H (OLS) are reported.<sup>53</sup> In some cases the H variables is now significant and has a systematic effect on predicted transactions prices reported below.

Turning to Table 6, we see that the basic structure of the transactions price equation estimates is very similar to the structure of the base price equation estimates. There is a premium for high quality (Btu content) coal and a penalty for high sulfur coal associated with post-1970 contracts. The sulfur penalty for contracts written between 1971 and 1973 is smaller and less significant than in the base price equations, however. As we shall see, contracts negotiated during this period of time yield transactions prices significantly below those for post-1973 contracts and the sulfur penalty is probably getting picked up in part by the time dummy for this period. Coal from the Western producing region carries a significantly lower FOB mine price than coal supplied from mines in the East and Mid-west. Thus, price adjustment provisions appear to preserve in later transactions prices the relative market value weights that are important for determining initial base prices.

To compare transactions prices in 1979, 1980 and 1981 for coal supplied

Table 6

Transactions Price Equations  
(standard errors in Parentheses)

Dependent Variable: Actual Transactions Price in 1979, 1980 or 1981.

Variable	1979 Transactions		1980 Transactions		1981 Transactions		Pooled Data	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	46.101 (26.857)	48.032 (25.815)	80.065 (31.028)	84.685 (30.751)	96.921 (36.319)	97.778 (37.125)	83.150 (17.607)	88.909 (17.538)
T1	-19.909 (10.286)	-36.392 (10.342)	-27.318 (12.446)	-37.625 (12.467)	-36.024 (13.843)	-47.931 (14.137)	-26.937 (6.790)	-40.064 (6.935)
T2	-21.427 (10.324)	-30.639 (10.119)	-28.410 (12.034)	-33.740 (11.756)	-35.402 (13.454)	-38.322 (13.377)	-28.252 (6.647)	-34.083 (6.618)
T3	2.117 (7.708)	-4.669 (7.704)	-2.653 (9.954)	-7.235 (9.852)	-13.319 (11.270)	-15.194 (11.360)	-3.251 (5.335)	-8.416 (5.399)
MIDWEST	5.452 (5.039)	7.702 (4.951)	5.430 (5.976)	5.874 (6.204)	-1.883 (7.283)	1.015 (7.615)	4.826 (3.596)	5.343 (3.481)
WEST	-36.280 (6.687)	-35.189 (5.669)	-44.368 (7.670)	-45.945 (7.997)	-51.923 (8.888)	-51.020 (9.673)	-42.536 (4.347)	-43.928 (4.535)
BTU	0.00705 (0.00201)	0.00776 (0.00191)	0.00576 (0.00227)	0.00612 (0.00221)	0.00666 (0.00265)	0.00693 (0.00264)	0.00678 (0.00131)	0.00698 (0.00127)
SULF1	-0.851 (2.651)	1.048 (2.569)	-1.032 (2.952)	0.339 (2.916)	0.233 (3.438)	1.870 (3.444)	-0.657 (1.689)	0.978 (1.682)
SULF2	-0.250 (4.328)	-1.625 (4.125)	-3.619 (4.743)	-5.374 (4.634)	-5.611 (5.594)	-7.106 (5.566)	-3.676 (2.742)	-4.564 (2.693)
SULF3	-11.278 (2.499)	-10.848 (2.395)	-13.024 (2.989)	-11.993 (3.003)	-11.493 (3.767)	-11.859 (3.754)	-12.268 (1.703)	-11.649 (1.693)
SULF4	-9.312 (3.147)	-11.550 (3.053)	-11.408 (4.304)	-12.768 (4.180)	-15.457 (4.920)	-16.614 (4.900)	-11.879 (2.261)	-13.530 (2.238)
H	-	-33.541 (14.690)	-	-45.033 (21.294)	-	-21.644 (28.788)	-	-36.956 (11.406)
PRICE-1979	-	-	-	-	-	-	-25.679 (2.428)	-24.181 (2.417)
PRICE-1980	-	-	-	-	-	-	-15.560 (2.483)	-14.642 (2.456)
R <sup>2</sup> (corrected)	0.48	0.52	0.51	0.54	0.55	0.56	0.56	0.57
NOBS	226	219	200	194	172	167	596	580

NOTE: One outlier has been dropped from 1981 transactions price equation (5).  
All three observations for the associated contract have been dropped from the  
pooled regressions. Observations for this contract do not appear in the  
equations with H because H was not available for these observations.



pursuant to contracts written at different points in time, it is useful to use the estimated relationships in Table 6 to "predict" transactions prices in each year (1979, 1980 and 1981) and on average for the 1979-81 period for contracts written in each of the four market periods. These comparisons are presented in Table 7 for equations estimated with and without H.

First, comparing Tables 5 and 7 it is clear that contract prices are "flexible" in the sense that they change over time, and as first order approximation, moved along with transactions prices in the market generally during this time period. Despite the very large differences in the initial base prices in contracts negotiated in different years, by the 1979-81 period mean transactions prices for contracts of different vintages are within a range of 10-15% of one another. The differences are largest when we make the censoring correction, which is not surprising since the greatest incidence of "missing" contracts is associated with relatively short contracts executed in the pre-1974 period.

Second, there are indeed some long run rigidities in price adjustment observed during the period of time covered by my data. Transactions prices observed in 1979, 1980 and 1981 are lower for pre-1974 contracts than for post-1974 contracts, as was expected. If we use the transactions prices for contracts negotiated in 1978 and 1979 as more closely reflecting market conditions in the 1979-81 period, the difference between pre-1974 and post-1974 contract transactions prices is on the order of 10-15%. The difference between transactions prices associated with 1974-77 contracts and later contracts is much smaller numerically and this difference is not statistically significant. The historical market conditions that characterized price formation in the pre-1974 period appear to affect transactions prices many years later.

TABLE 7

Predicted Transaction Price By Contract Execution Period  
(cents per million btu's)

<u>Contract Era</u>	<u>Single Year Transaction Data</u>						<u>Pooled Data</u>	
	<u>1979</u>		<u>1980</u>		<u>1981</u>		<u>OLS</u>	<u>OLS/H</u>
	<u>OLS</u>	<u>OLS/H</u>	<u>OLS</u>	<u>OLS/H</u>	<u>OLS</u>	<u>OLS/H</u>		
Pre-1971	99.7	93.1	106.3	101.9	121.6	115.4	108.4	102.5
1971-1973	99.4	93.7	100.4	95.2	111.7	108.9	101.3	98.2
1974-1977	101.8	102.1	108.7	109.3	123.3	123.5	110.3	110.6
1978-1979	103.5	105.4	112.3	115.1	129.5	130.2	114.3	115.5

Source: Predicted Values from Equations in Table 6 using the sample means for the independent variables. Coal characteristics and regional mix are thus held constant for purposes of generating the comparative information above. OLS/H refers to those equations that include H.

The pricing behavior that we observe is perfectly consistent with the use of BPE and cost plus adjustment provisions during an era in which demand grew and production costs increased. We observe both the flexibility and the rigidity that these adjustment mechanisms are likely to exhibit. The price difference observed for 1979-81 is probably too large to be completely explained by changes in the long run price trajectory pre and post 1974, due to changes in demand expectations. Cost side rigidities and short run price effects probably explain part of the difference as well.<sup>54</sup>

These results suggest that the written provisions of contracts are in fact meaningful since we do find systematic differences in transactions prices between contracts negotiated in different periods of just the type we would expect to observe given the structure of price adjustments provisions and the nature of changes that took place in coal markets during this period of time. If formal contract provisions were not particularly meaningful and the parties simply renegotiated prices each year (for example), I would have expected to find no systematic differences in transactions prices associated with the period of time that contracts were negotiated.

While the results for the pre-1974 contracts as a group are consistent with expectations, the results for the pre-1971 contracts are a little bit puzzling. Although 1979-81 transactions prices are lower for these contracts than for the post-1974 contracts, the difference is smaller than that for the contracts signed immediately before 1974. My expectation was that these contracts would have performed especially poorly given what was expected when they were written.

The most likely explanation for this result is that these contracts really did perform quite poorly after 1973 in tracking cost changes as costs of all kinds increased at rates and in ways not anticipated when they were

written. Indeed they may have performed so poorly that the sellers could credibly appeal to gross inequity and force majeure provisions or credibly threaten to breach through bankruptcy to force renegotiation of escalation provisions sometime in the mid or late 1970's. In some cases, buyers may have been quite willing to renegotiate to reduce take or pay requirements where emissions regulations reduced the demand for previously contracted for coal. Such renegotiations would probably have resulted in escalation provisions similar to those being negotiated in contemporary contracts and some adjustment in base prices to reflect past cost increases that had not been reflected in prices. There is no reason to believe that buyers would have agreed to move prices up to then prevailing market levels, however, if this was not necessary to make continued performance economical for the seller.

There is no obvious way to test systematically this hypothesis without obtaining complete histories of contracts and contract renegotiation for the observations in my data base. This would be impossible. I have put together a reasonably complete contractual history for one coal contract negotiated about 1960 which I believe is informative. The contract involves the supply of coal to the Four Corners Generating Station in New Mexico (a mine-mouth plant). The first contract was executed in 1960 and covered deliveries for three generating units to be built at this site, with options to extend supply commitments for additional units. A second related contract was executed in 1966 to cover coal supplies for two additional (and much larger) generating units.

The 1966 contract uses a BPE adjustment formula. The base price is broken down into six different components. All but one of these components is indexed in some way. The non-escalating component includes profits, rents and some depreciation. The contract includes a gross inequity provisions, but does not



include a specific provision for recovery of costs associated with new government regulations. Prior to 1975, there were several technical amendments to the contracts, but these did not affect prices levels or the price adjustment formula. In 1975, the contract was amended to allow for the recovery of costs associated with land reclamation expenses resulting from the New Mexico Coal Surface Mining Act. In 1977, the contract was amended again to allow for the recovery of new severance taxes imposed by the State of New Mexico. On January 1, 1981 the escalation provisions in the 1966 contract were revised. The seller appealed to the portion of the contract that provided for "... revision of methods of price escalation if there should occur extreme or radical changes from economic factors and conditions which existed at the time of negotiation...which seriously distorted or rendered clearly inequitable the application of the methods of escalation set forth in the Agreement."

The new pricing formula added a complicated "inflation/deflation" component to the price which provides for additional adjustments for changes in production costs that were sustained since mid-1979. It also provides for monthly adjustments of those components that had previously been adjusted annually. Recovery of costs associated with compliance with new environmental regulations is provided for, is laid out in great detail and the provision appears to include recovery for cost incurred prior to 1981 if they have not already been incorporated in the base price through previous amendments. Finally, the amendment gives the buyer or seller the right to seek a lower/higher price after five years if the seller's rate of return on investment significantly exceeds or falls short of the "normal" rate of return for a similar business.

To the extent that other contracts executed during the 1960's went through similar adjustments in the late 1970's as did the Four Corners Agreements,



this would help to explain the pricing patterns observed for pre-1971 contracts.

While coal contracts written between 1960 and 1978 appear to have adjusted fairly well on average to changing market conditions, as revealed by comparative transactions prices in 1979, 1980 and 1981, this does not mean that all of the contracts did so.<sup>55</sup> To get some sense for how far off adjustment formulas can lead prices I have examined a set of outlier contracts associated with both the base price and later transactions price relationships. An outlier was defined as an observation that had a Studentized residual with an absolute value of more than 1.96.<sup>56</sup> In the base price equation there were 13 contracts that met this criterion. Seven of the contracts have negative and six positive residuals. The large negative residuals are primarily associated with contracts written in 1974. I suspect that these contracts were initially negotiated before market conditions tightened. The large positive residuals are primarily associated with earlier contracts. Only one of these 13 contracts, however, shows up as an outlier in the transactions price equations. This raises the possibility either that these contracts had atypical adjustment provisions, or that the base prices were subsequently renegotiated.

When we turn to the transactions price relationships I identified 22 contracts that met the outlier criterion in at least one of the equations.<sup>57</sup> The outliers come from all regions, all contract execution periods, and are associated with contracts of varying durations. The absolute value of the residuals is roughly 50% of the expected price. For 20 of these contracts we can match the 1979-81 transactions prices with the associated base price. With one exception these contracts were not outliers in the base price equation, so they appear to have had adjustment provisions that led "typical" base prices

to become "atypical" transactions prices over time. other things equal. Furthermore, the distribution of outliers is not symmetric. Sixteen of the twenty-two contracts have large positive residuals, meaning that actual transactions prices are much higher than predicted. Only six have large negative residuals. This suggests that the adjustment provisions were more likely to get far off on the high side than on the low side. Most of the sixteen contracts with large positive residuals are either post-1973 contracts (13) or earlier contracts that used a cost-plus adjustment mechanism (2). Of the six contracts with large negative residuals, only one was signed before 1974. Three of the six contracts were signed by the same utility at about the same time.

Since only one of the outliers associated with the transactions price equations also appeared as an outlier in the base price equation, it does not appear that these outliers are associated with special coal characteristics that are not being measured properly in the price relationships. However, of the fifteen contracts with large positive transactions price residuals for which we can match base price information, twelve had positive, though not necessarily large, residuals in the base price equation as well. This suggests that for some reason these contracts had prices that started out higher than expected and got further and further from their expected value over time. (There is nothing particularly noteworthy about the three other contracts with positive residuals.) Of the five contracts with large negative residuals which we can match with base prices, two also had negative, though not necessarily large, residuals in the base price equation. The prices in these contracts got lower and lower compared to the expected value over time. The remaining three contracts with negative transactions price residuals had positive residuals in the base price equation. These contracts were written at about the same time

by the same utility, but for coal from different supply regions. This suggests that this particular utility may have chosen to rely on contracts which incorporated a significant fixed price component in the base price.

While the contracts as a group adapted to changing market conditions fairly well, it is clear that individual long term contracts that specify the way prices will be determined over time ex ante can eventually yield transactions prices that are way out of line with prevailing market conditions.

#### V. Conclusions

Relationship specific investments often make it desirable for electric utilities and their coal suppliers to enter into long term contracts. A major challenge in structuring such contracts involves the specification of price adjustments provisions that both guard against opportunistic behavior and do not lead to serious adaptation problems as the contractual relationship plays itself out. The kinds of price adjustment mechanisms that are typically relied upon in long term coal contracts appear to have been reasonably successful in responding to this challenge during the 1970's and early 1980's.

The contractual adjustment provisions in long term contracts provide for price flexibility at least in response to changes in the costs of production but also embody some potential long run rigidities. Between 1970 and 1981 nominal coal prices increased by a factor of about four. Real coal prices doubled. Yet transactions prices pursuant to long term contracts tracked prevailing market conditions during the 1970's quite closely. While we find some significant rigidities in contract prices, the price disparity between contracts of different vintages resulting from these rigidities is on the order of only about 10- 15% on average by the 1979-81 period. While a 15% difference in average transactions prices is far from being trivial it is

still relatively small compared to the overall movement of prices in the market over time. There is also some evidence that some individual contracts did very poorly in tracking changing market conditions during this time period and exhibited substantially more rigidity in this sense than the average contract. At least during the time period studied here, the contractual provisions in long term coal contracts did a fairly good, but far from perfect, job of adapting to changing market conditions. It will be interesting to see in future research how these contracts performed as time went on and the coal market softened considerably.



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<sup>2</sup> Paul L. Joskow, Vertical Integration and Long Term Contracts: The Case of Coal, 1 Journal of Law, Economics and Organization 33 (1985) and Paul L. Joskow, Contract Duration and Relationship Specific Investments: Empirical Evidence From Coal Markets, 77 American Economic Review \_\_\_\_ (1987).

<sup>3</sup>The literature is discussed in Joskow (1985) and (1987) supra, note 2, and Paul L. Joskow, Long Term Vertical Relationships and the Study of Industrial Organization, 141 Journal of Theoretical and Institutional Economics 586 (1985).

<sup>4</sup>See especially Oliver Williamson, Credible Commitments: Using Hostages to Support Exchange, 73 American Economic Review 519 (1983), Benjamin Klein, Robert Crawford and Armen Alchian, Vertical Integration, Appropriable Rents and the Competitive Contracting Process, 21 Journal of Law and Economics 297: (1978), and Oliver Hart and Bengt Holmstrom, The Theory of Contracts, Working Paper #418, Department of Economics, MIT (March 1986). Keith Crocker and Scott Masten, Mitigating Contractual Hazards: Unilateral Options and Contract Length, Working Paper #449, Graduate School of Business, University of Michigan (1986), examines the duration of natural gas contracts in the context of a model that tries to measure both the costs and benefits of long term contracts. Scott Masten and Keith Crocker, Efficient Adaptation in Long-Term Contracts: Take-or-Pay Provisions For Natural Gas, 75 American Economic Review 1083 (1985), discusses take-or-pay provisions in natural gas contracts.

<sup>5</sup> Victor Goldberg's papers are the only ones that I am aware of which explore this question with information from real contracts. Victor Goldberg, Price Adjustment in Long-Term Contracts, 1985 Wisconsin Law Review 527 (1985), and Victor Goldberg and John Erickson, Long Term Contracts for Petroleum Coke, Working Paper No. 206, Department of Economics, University of California at Davis (1984).

<sup>6</sup>Dennis Carlton's recent paper is a notable exception. Dennis Carlton, The Rigidity of Prices, 76 American Economic Review 637 (1986).

<sup>7</sup>Of a sample of 160 coal contracts in force in 1979 and that had contractual termination dates in 1983 or later, I found that all but three continued to operate in 1983 despite significant changes in coal markets between 1979 and 1983.

<sup>8</sup> Joskow (1985) and (1987), supra, note 2

<sup>9</sup> Williamson, supra, note 4 at 526. As in my early papers on coal supply arrangements, I ignore risk sharing explanations for the reliance on and structure of long term contracts. See A.M. Polinsky, Fixed Price vs. Spot



Price Contracts: A Study In Risk Allocation, 3 Journal of Law, Economics and Organization \_\_\_\_ (1987), for a discussion of the role of risk sharing considerations in the choice between fixed price and market price contracts.

<sup>10</sup>The long run supply function for coal to U.S. utilities is upward sloping, although it appears to be fairly elastic. As a result, Hotelling type "user costs" associated with resource depletion are relatively small. See Martin Zimmerman, The U.S. Coal Industry: Economics of Policy Choice, MIT Press, Cambridge, MA (1981) at 91-93

<sup>11</sup>These economic rents will not necessarily accrue to the coal supplier since the rights to mine the coal often must be secured from third parties.

<sup>12</sup>For example the contract is long enough to pay off fully the relationship specific component of investments made by the seller and/or that notice, termination and damage provisions otherwise provide for the recovery of losses due to premature termination.

<sup>13</sup>The terms and conditions of coal contracts negotiated between a coal supplier and an electric utility are not regulated directly by state public utility commissions. The costs of coal purchased under long term contract would generally be treated like any other fuel cost and passed on in final electricity prices through a fuel adjustment clause. Regulatory agencies can deny cost recovery, however, if they determine that the utility has signed an "imprudent" contract. Regulatory agencies have sometimes disallowed fuel purchased pursuant to long term contracts. Regulatory agencies are likely to become especially interested in prudence issues when contract prices appear to be higher than what other buyers are paying for coal.

<sup>14</sup>Court awarded damages aside, the buyer is not in a good bargaining position since contract prices may be significantly below the price of his next best alternative.

<sup>15</sup>The seller will attribute any shortfalls in quantity or quality to factors outside his control or try to exploit ambiguities in the terms of the contract. Especially if cost increases result from changes in government regulation or union work rules and prices are less than identifiable production costs, the seller may try to rely on vague doctrines of commercial impracticability or force majeure to prevail in court. Bankruptcy may very well be an attractive strategy for the seller in some cases.

<sup>16</sup> A simple numerical example is useful for understanding the nature of the performance problems that emerge with fixed price long term contracts. The average cost of production from a typical mine is composed of operating costs that are variable in the short run and capital related costs which are not. The breakdown is roughly 75% short run variable costs and 25% costs that are fixed in the short run. With reasonable assumptions about expected inflation rates and interest rates during the 1970's, a 20 year fixed price contract which satisfies (1) will have a price that falls below the then current variable costs of production after between 10 and 15 years if inflationary expectations are realized. It would be economical for the supplier to shut down at this point assuming that all capital related costs are sunk in year zero. If we recognize that capital investments actually are made fairly continuously through the life of a mine, the shutdown point could be much sooner. A twenty year commitment will simply not be credible if the seller is expected to have strong financial incentives to walk away from the deal in the

middle of the contract even if all expectations about costs and market values are realized exactly. A set of numerical simulations that amplify on this discussion are available from the author.

<sup>17</sup>With a fixed price contract and expected increases in nominal production costs and market values over time, in order to satisfy (1) the contract price is likely to start out being higher than the then current average transactions price and end up lower. If the regulatory agency compares contract prices with average transactions prices in the early years of the contract the difference in prices may lead to an unjustified disallowance. This would not be made up with a reward in later years. Using the same numerical example as reported above, the initial base price for coal pursuant to a twenty year fixed price contract could be 50% to 70% above the then prevailing average cost of production.

<sup>18</sup>Since transportation costs are a large fraction of the buyer's ultimate cost of coal and neither supply nor consumption is uniformly distributed across the country, prices at the mine will vary from location to location.

<sup>19</sup>The econometric analysis reported below confirms these assertions regarding the market value of coal quality and location.

<sup>20</sup>There is for delivered prices, but these include transportation costs.

<sup>21</sup>The buyer could argue of course that he must pay more than "the market price" to replace the contract and the seller could argue that he must accept less than "the market price" to dispose of the supplies, but this just gets us back to the problem of defining a meaningful market price.

<sup>22</sup> For example, if there is an unexpected short run increase in demand, short run market values may increase faster than average production costs in the short run. If the shift in demand is permanent the expected trajectory of future prices may rise as well if there is a significant long run economic rent component in the market value of coal. Or the demand for coal could fall suddenly, there could be a lot of resulting excess capacity and prices would fall to reflect this situation. If the reduction in demand is permanent, the expected trajectory of future prices could shift down if there is a significant economic rent component in the average contract price.

<sup>23</sup>Fixed price contracts become more viable from this perspective as the agreed upon duration of the agreement gets shorter and the magnitude of changes in expected nominal production costs and market values over the term of the agreement gets smaller.

<sup>24</sup>Market price provisions will be more viable when the quasi-rents associated with relationship specific investments are small.

<sup>25</sup>These contracts generally have durations of greater than four years.

<sup>26</sup>Over fifty of which are also represented in the data base discussed in the Appendix.

<sup>27</sup>The source that I relied on for the information in Table 1 did not generally provide more detailed information than a simple categorization of the price adjustment formula. Based on actual contracts that I have reviewed it is likely that at least some of the BPE contracts have "reopener" provisions that

allow for renegotiation at some point in time or when certain contingencies occur.

<sup>28</sup>Although I have all of the information required for the econometric analysis reported below for only 247 of these contracts.

<sup>29</sup>Between 1973 and 1978 coal accounts for a slightly declining fraction of electricity production. Oil's share is about constant. Nuclear's share increases by a factor of almost three as nuclear facilities committed before 1973 were completed. It is only after 1978 that fuel oil consumption declines dramatically and utilities rely much more on coal for generating electricity.

<sup>30</sup>Oil consumption by electric utilities does not begin to decline significantly until after 1978.

<sup>31</sup>The Fuel Use Act of 1978 restricted the use of oil or gas in new utility boilers as well.

<sup>32</sup>Setting the stage for a subsequent collapse in spot and new contract prices after roughly 1983. This later period is the subject of ongoing research.

<sup>33</sup>Federal Coal Mine Health and Safety Act of 1969.

<sup>34</sup>e.g. The Federal Mine Safety and Health Act of 1977 and related state laws.

<sup>35</sup>e.g. The Surface Mining Control and Reclamation Act of 1977, Federal Water Pollution Control Act, Solid Waste Disposal Act, Safe Drinking Water Act, Soil and Water Resource Conservation Act and related state laws.

<sup>36</sup>These input prices were no doubt affected by increased demand for the same inputs by the oil and gas drilling sectors and by uranium mining which also expanded at the same time.

<sup>37</sup>See Paul L. Joskow and Richard Schmalensee, The Performance of Steam Electric Generating Plants in the U.S.: 1960-1980, \_\_\_\_ Journal of Applied Econometrics \_\_\_\_ (in press).

<sup>38</sup>See Richard Schmalensee and Paul L. Joskow, Estimated Parameters as Independent Variables: An Application to the Costs of Steam Electric Generating Units, 31 Journal of Econometrics 275: (1986)

<sup>39</sup>The Clean Air Act of 1970 and associated regulations affecting existing sources and new sources are especially important.

<sup>40</sup>See Williamson, supra, note 4. For example, suppliers might try to recover relationship specific investments quickly by seeking higher base prices but lower escalation rates rather than dealing with differences in the importance of relationship specific investment by adjusting the term of the agreement as I suggested earlier. Buyers might try to protect themselves with lower base prices and higher escalation rates.

<sup>41</sup>All prices are FOB the mine and are expressed in nominal cents per million Btu's.

<sup>42</sup>Joskow (1987), supra, note 2.



<sup>43</sup>Ibid.

<sup>44</sup>See George Judge et. al., The Theory and Practice of Econometrics, Wiley, (1985) at 610-613, James Heckman, The Common Structure of Statistical Models of Truncation, Sample Selection and Limited Dependent Variables and a Simple Estimator for Such Models, 5 Annals of Economic and Social Measurement 475: (1976), and James Heckman, Sample Selection Bias As A Specification Error, 47 Econometrica 153: (1979).

<sup>45</sup>The number of observations varies somewhat from equation to equation because of missing data. I do not have information on contract duration for four observations. Values for H are not available for six observations.

<sup>46</sup>There does not appear to be a contract quantity effect either. When a variable measuring contract quantities is introduced, its coefficient is not significantly different from zero.

<sup>47</sup>The results are not sensitive to the relationship chosen from Table 4.

<sup>48</sup>The average transactions price at a particular point in time is of course an imperfect indicator of prevailing market conditions as they affect prices pursuant to new long term contracts. The average transactions price includes both spot transactions and contract transactions. Spot market transactions were unusually high in 1974 and 1975 and spot prices are likely to have jumped considerably in these two years as well. There does not appear to be a separate series for spot prices FOB the mine. However, 24% of coal delivered to electric utilities in 1974 and 18% in 1975 was spot coal, compared to an average of less than 15% for 1976-1982. See Joskow (1985, p. 53). The average transactions price figure also averages prices pursuant to contracts negotiated in many different years. If there are price rigidities, we would expect to find some differences between base prices in new contracts and contemporaneous average transactions prices.

<sup>49</sup>Obviously I do not have transactions price information for each contract in each of these years. Aside from reporting gaps, some of the contracts in the data base came to an end in 1979, 1980 or 1981.

<sup>50</sup>DURATION is never significantly different from zero in the transactions price equations, so I have not bothered to report estimates with it included.

<sup>51</sup>The long run supply function for coal sold in the U.S. appears to be quite elastic. As a result, the long run price effects of even large increases in the expected demand for coal should be modest. Zimmerman's calculations suggest that large changes in the expected demand for coal would change prevailing market prices by only 10% to 20% in the year 2000. The long run Hotelling rent component of prices in 1980 associated with such an increase in coal demand over the long run should be quite small. See Zimmerman, supra, note 10, at 91-98.

<sup>52</sup>To the extent that adjustment provisions include adjustments for average changes in productivity rather than changes attributable to a particular mine, some of the increases in economic rents may be captured by the pricing

provisions in existing contracts.

<sup>53</sup>When the equation for 1981 transactions was first estimated, I detected one contract that was a very large (six standard deviations) outlier. The associated reported price is much higher than anything else in the sample and much higher than it was in 1980. The observation was dropped from the 1981 transactions equation and the associated contract was dropped from the pooled regression equations. This turned out to be a contract for which H is not available, so that this contract does not appear in any of the equations including H. This contract is not an outlier in the base price equation, however. Outliers are discussed in more detail below.

<sup>54</sup>When this work is extended to the post 1983 period I expect to observe downward rather than upward price rigidities.

<sup>55</sup>Nor does it mean that large differences did not emerge later. Coal markets softened considerably after 1981 and when the data are available it will be interesting to see how transactions prices pursuant to these contracts compared to prices charged in new long term contracts in (say) 1984 and 1985. I plan to explore this further when the data become available to me.

<sup>56</sup>See David A. Belsley, Edwin Kuh, and Roy E. Welsch, Regression Diagnostics, Wiley, 1980, p. 17.

<sup>57</sup>The transactions price equations were reestimated without these contracts as well. The key results reported earlier were unaffected. The outliers consistently have large residuals in each transaction year 1979-81.



## Appendix

### Contract Data Base

The data base that I make use of to estimate the base price and transactions price equations discussed in the body of the paper was constructed for this analysis from information contained in The Guide To Coal Contracts (Pasha Publications, Arlington, VA, 1981 and 1983 Editions). The 1981 Edition contains information for coal contracts executed prior to 1980 based on reports filed by investor-owned utilities with the Federal Energy Regulatory Commission. The 1981 Edition picks up information on the initial base price specified in each contract when this information was provided by the utility to the FERC. Base price information is not contained in subsequent Editions of The Guide To Coal Contracts. This source was also used to obtain information on coal characteristics and the location of mines. The 1983 Edition reports transactions prices by contract for 1979, 1980 and 1981. To be included in the data base, contracts had to appear in both Editions and all information required for the analysis provided.

The 1981 and 1983 Editions of the Guide To Coal Contracts provided no information on price adjustment provisions. The 1985 Edition (which was released after the primary data set was constructed) did provide such information for some contracts. I used the 1985 Edition of the Guide To Coal Contracts along with information I obtained from a set of actual coal contracts to obtain the information that is reported in Table 1.

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